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10.1 INTRODUCTION

10.1.1 Background

Floodwaters from upstream rivers are considered a primary threat to levees in the south Sacramento–San Joaquin River Delta (Delta). Federal Emergency Management Agency mapping of the 100-year floodplain in this area is ongoing, and several San Joaquin County communities have been notified that their levees may not receive 100-year accreditation. These levees include those along the Calaveras River through the heart of Stockton, those protecting high-risk flood neighborhoods such as Weston Ranch and Mossdale, and those along the Smith Canal protecting the Country Club and Louis and Victory Park areas.[1] Without significant changes, these areas are at risk during flood events.

Both the Public Policy Institute of California, in its publication *Envisioning Futures*, and the Natural Heritage Institute, through John Cain, Director of Restoration Programs, have proposed creating flood protection for Stockton and adjacent towns along the east bank of the San Joaquin River by bypassing floodwaters through Stewart Tract. They note that historical, unintentional breaches of Stewart Tract levees during flood events have prevented flooding of adjacent communities. They cite, for example, the 1997 San Joaquin River flood, in which a Stewart Tract levee failed and flooded the island, relieving pressure on neighboring levees and protecting downstream areas from over 107,700 acre-feet/day of water pouring down San Joaquin River in an enormous, protracted flood event.[2] The proposals by the Public Policy Institute and John Cain suggest making this accidental historical protection permanent by diverting San Joaquin floodwaters onto Stewart Tract and through a bypass system similar to the Yolo Bypass, which protects the city of Sacramento.

10.1.2 Scope

The scope of this building block includes development and evaluation of concepts that use all or portions of Stewart Tract and Roberts Island to divert San Joaquin River floodwaters away from the populated areas along the east bank of the river between Lathrop and Stockton. Two alternatives are investigated. Alternative 1 is a true bypass system, in which floodwaters are diverted into a separate channel or floodway on Stewart Tract and Roberts Island that is isolated from the main stem of the San Joaquin River, with river water diverted south of Lathrop and discharged back into the river north of Stockton. Alternative 2 involves creating a floodplain by construction of a setback levee along the west bank of the San Joaquin River such that floodwaters are spread onto portions of Stewart Tract and Roberts Island, thereby lowering water surface elevations next to developed areas.

The scope of this analysis is conceptual; the intent is to determine whether further detailed studies of either alternative for flood protection are worthwhile.

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[1] http://www.recordnet.com/apps/pbcs.dll/article?AID=/20070623/A_NEWS/706230319.

[2] http://www.recordnet.com/apps/pbcs.dll/article?AID=/20050531/SPECIALREPORTS04/50920008; see also http://landscape.ced.berkeley.edu/~delta/opeds/SB_Apr1106.pdf.

10.1.3 Purpose

The purpose of Building Block 1.8: San Joaquin Bypass, is to evaluate two alternative flood bypass or equivalent plans for Stewart Tract and Roberts Island, which include floodplain habitats. This evaluation involves identifying flood protection and habitat goals, evaluating methods to reach the goals, and creating plans and cost estimates for implementing the plans. The objectives are twofold. The first objective is to protect lives and property in Lathrop, Mossdale, Stockton, and adjacent communities during flood events. The second objective is to create a floodplain habitat and if feasible, marshland to provide more habitats for fish, waterfowl, and wildlife, and improved aquatic foodweb production and water quality, as described in the Bay-Delta Ecosystem Restoration Program Plan (BDCP 2000). An overview of each alternative is presented in Figures 10-1 (Alternative 1) and 10-2 (Alternative 2).

10.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

10.2.1 Description of Current Project Lands, Zoning, and Infrastructure

The Delta lands considered in this building block are currently used primarily for agriculture. Stewart Tract land has been placed in the secondary zone of the Delta by the 1992 Delta Protection Act; this land may be developed for residential use. Stewart Tract is owned by the Cambray Group, which has proposed development of 11,000 residences on the flood-prone island.[3] The land composing Lower, Middle, and Upper Roberts Island, which has mixed private and public ownership, is within the Delta's Primary Zone;[4] no residential development may be added.

Interstate Highway 5 crosses the southern end of Stewart Tract, between the intersections of Interstate 205 to the west and State Route 120 to the east. It runs along a raised berm several feet higher than adjacent levees, and should not be overtopped during flood conditions.

Roberts Island is crossed by State Route 4, which is not raised and can therefore be flooded under current conditions if Roberts Island floods, as can all other roads and railroads on both islands. Tables 10-1 and 10-2 catalog the current linear and nonlinear infrastructure on these islands.

10.2.2 Description of Alternative Projects

Two alternatives are considered to meet the building block objectives. In both alternatives, the area considered for "bypass" development is the southeastern Delta west of Mossdale, Manteca, and Stockton and includes all or portions of both Stewart Tract and Roberts Island.

10.2.2.1 Alternative 1: San Joaquin River Detention and Bypass

In Alternative 1, low-level weirs would be provided in the west bank levee of the San Joaquin River between Lathrop and Stockton. These weirs would direct excess floodwater out of the San Joaquin River into Stewart Tract or, if necessary, into both Stewart Tract and Roberts Island. The

[3] http://dwb.sacbee.com/content/opinion/story/14244595p-15063041c.html.

[4] http://www.delta.ca.gov/recinvty.asp.

diverted floodwater will either be detained until the flood event has passed or, once the storage capacity of Stewart Tract and Roberts Island is approached, released via weirs that direct the flow away from developed areas (Figure 10-3). This alternative requires a flood easement for both Stewart Tract and Roberts Island. As currently envisioned, this bypass plan will require construction of six weirs and two flap gates within the current Stewart and Roberts levees. Intermittent/occasional floodplain habitat is created by this plan over the whole of both islands, which will remain as agricultural land between flood events.

The following actions would be needed to develop San Joaquin Bypass Alternative 1:

- Acquisition of flood easements on Stewart Tract and Roberts Island
- Construction of a weir along the southeastern edge of Stewart Tract to channel floodwaters from San Joaquin River into Stewart Tract during flood events
- Construction of a 0.5-mile causeway to allow flood flows to pass under Interstate Highway 5
- Construction of a flap gate outlet (North Stewart Drain) at the northern edge of Stewart Tract to provide for gravity drainage of the tract after a flood event
- Construction of an overflow weir along the northern levee of Stewart Tract to channel excess floodwater into Middle River in the event that Stewart Tract's storage capacity is exceeded during a flood event
- Construction of three weirs along the south and east levees of Roberts Island to channel floodwater that cannot be contained in Stewart Tract and Middle River into the island
- Construction of overflow weirs to allow passage of excess floodwater through Roberts Island and into San Joaquin River at the north end of the island during flood events that exceed the combined storage capacity of Stewart Tract and Roberts Island
- Construction of a flap gate outlet (North Roberts Drain) at the northern edge of Roberts Island to provide for gravity drainage of the tract after a flood event

10.2.2.2 Alternative 2: San Joaquin River Widening

In Alternative 2, a new setback levee would be built along the eastern edge of Stewart Tract and Roberts Island about 0.5-mile west of the current San Joaquin River west bank levees (Figure 10-4). The existing west bank river levee will be removed. Permanent floodplain habitat will be created in the 22-mile-long, 0.5-mile-wide area between the San Joaquin River and the new setback levee. The 7,040-acre area of floodplain habitat will have the potential to be managed as marsh and floodplain.

The following actions would be needed to develop Alternative 2:

- The purchase of an approximately 0.5-mile-wide strip of land next to the west toe of the west San Joaquin River levee between the south end of Stewart Tract and the north end of Roberts Island
- Construction of new levees (setback levees) along the western edge of the half-mile strip of acquired land
- Construction of two highway bridges and two major road bridges across the widened floodplain

- Removal of the current San Joaquin River west-bank levees between the south end of Stewart Tract and the north end of Roberts Island
- Creation of a floodplain habitat on the 0.5-mile strip of land between the setback levees and San Joaquin River
- Relocation of about 6 miles of major and minor roads

10.2.3 Analysis Criteria and Basis of Design

10.2.3.1 Basis of Design: Historical Flooding

San Joaquin River has exceeded flood stage ten times in the 84 years of record since 1923 (average return frequency of 8.4 years) and exceeded moderate flood stage five times in the 84 years of record (average return frequency of 16.8 years). The flood stages of the San Joaquin River at Vernalis and Mossdale are presented in Table 10-3, and the flood events in which the San Joaquin River reached flood stage are summarized in Table 10-4. Levee breaches occurred on Stewart Tract during the floods of 1938, 1950, and 1997, flooding the tract three of the five times the San Joaquin River reached moderate flood stage at Vernalis. During these three flood events, the levee breach diverted floodwaters onto the tract, thereby reducing downstream peak flows and water-surface elevations.

In early 1997, a combination of unseasonably warm temperatures, full reservoirs, and heavy rainstorms caused the largest flood in the 90 years of records that the Department of Water Resources has maintained for Northern California.[5] Flooding occurred throughout the Sacramento and San Joaquin Rivers, with levee failures throughout the system. Over 120,000 people were evacuated, nine people died, 300 square miles were flooded, and 23,000 homes, businesses, roads, and bridges were damaged[6] throughout the Delta. In what is now considered to be a fortuitous breach, a Stewart Tract levee failed and allowed inundation of the island, which relieved pressure on other levees in the system and attenuated peak downstream flows in lower Stockton neighborhoods and the fragile Delta. Without breaching of the Stewart Tract levee in 1997, up to 54,300 cubic feet per second (cfs), peak flow at Vernalis Station, would have been channeled directly into the most vulnerable areas of downtown Stockton. For purposes of this building block, the flow measured at Vernalis Station during the historic flood of 1997 is used as the basis to size and evaluate alternative project facilities for both Alternative 1 and Alternative 2.

10.2.3.2 Alternative 1: Detention and Bypass Basis of Design

Intentional flooding of Stewart Tract during large storm events would provide immediate relief to downstream levees and allow storage of water until the flood event has passed. Stewart Tract has a capacity to store about 47,400 acre-feet of floodwater below elevation 11 feet (North American Vertical Datum of 1988 [NAVD88]), the minimum elevation of the tract’s surrounding levee. By incorporating Roberts Island into a flood bypass, an additional 369,875 acre-feet of storage capacity below 9 feet (NAVD88) is added (Table 10-5). Storage capacities in

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[5] http://www.news.water.ca.gov/1998.fall/SJwaters.html.

[6] http://dwb.sacbee.com/content/opinion/story/14244595p-15063041c.html.

relevant portions of Stewart Tract and Roberts Island are summarized in Table 10-5. In the event that available storage capacity is exceeded, water would be routed downstream of Stockton and away from developed areas, something that is not possible if flooding occurs on Stewart Tract alone.

Through a combination of detention storage and flow bypass, Alternative 1 would provide reduced peak flows and associated water-surface elevations in the main stem of the San Joaquin River past the developed areas of Stockton, Mossdale, and Lathrop. The concept would limit the maximum water-surface elevation to the local flood stage by the following measures:

1. First provide for floodwater detention in Stewart Tract
2. If Stewart Tract storage capacity is exceeded, provide for spill from Stewart Tract to Roberts Island and for additional diversion from the San Joaquin River to Roberts Island to detain additional floodwater in Roberts Island
3. If the combined storage capacity of Stewart Tract and Roberts Island is exceeded, provide for floodwater to exit Roberts Island downstream from Stockton.

10.2.3.3 Alternative 2: River Widening Basis of Design

The Alternative 2 concept is to widen the river to increase its flood-carrying capacity such that during the design flood (the 1997 flood event); the river next to developed areas will be at or below flood stage at the peak of the flood event.

10.2.4 Analysis Results and Design Layouts

To estimate the level of protection provided by the two alternatives and to provide a basis for comparing the alternatives to each other, a simple HEC-RAS (USACE 2006) model was developed for a portion of San Joaquin River. The model extends from just south of Stewart Tract to the middle of McDonald Island. It includes San Joaquin River, Stockton Deep Water Ship Channel, and Burns Cutoff. Inflows from the Calaveras River, which joins the San Joaquin River at the northern end of Rough and Ready Island, and from other sloughs and channels, such as Middle and Old rivers, were not included. Although the model is simplistic in its representation of the San Joaquin River and the Delta, it should provide sufficient detail to adequately compare the alternatives.

Figure10-5 shows the cross sections used in the model and their locations. The cross sections were obtained from the topographic and bathymetric Geographic Information System model developed for Phase I of the Delta Risk Management Strategy project. For model simulations, additional cross sections were interpolated at 500-foot intervals (minimum) between each cross section. For Alternative 1, Stewart Tract and Roberts Island would be flooded to provide flood protection to east bank and downstream communities. These islands were treated as ponds connected to the San Joaquin River with a side channel weir. The stage storage used for the islands is shown in Table 10-5. The locations of the weirs are shown on Figures 10-3 and 10-5. For Alternative 2, the west bank levee of the San Joaquin River is moved westward 0.5 mile (Figures 10-4 and 10-6).

Simulations were conducted for four storm events, January 1969, February 1998, April 2006, and January 1997. These flows represent four of the six largest flows since 1969. The flood of January 1997 is the largest flood of record and is the basis of design for these alternatives. For the downstream boundary, a fixed water surface elevation of 6.0 feet (NAVD88) was used. This water surface elevation corresponds to the approximate average water surface elevation at Venice Island for the April 2006 storm.

The results of the analyses of the four flood events are shown on Figures 10-7 through 10-10. For each flood event, the alternatives are compared to the existing conditions. The results are also summarized in Table 10-6 for the January 1997 storm. The results for Alternative 1 represent maximum benefits. It was assumed that the island outlet weirs would not cause a backwater on the inlet weirs, and therefore water was free to flow from the river into the islands. For short-duration, moderate-flow events, water would enter Stewart Tract via a weir and be stored in the tract, thereby reducing the water surface elevation in San Joaquin River and preventing flow from the river into Roberts Island. For long-duration, high-flow events, Stewart Tract would fill to the level at its northern outlet weir crest and discharge through the inlet weir at the south end of Roberts Island. Also, flows through Stewart Tract may not be sufficient to prevent river flow from entering Roberts Island via the project weirs along the east boundary of the island. The biggest flood protection benefits are obtained south of Rough and Ready Island. South of Rough and Ready Island, the decrease in water surface elevation could be as much as 10 feet for either alternative, though this result should be considered approximate due to the simplistic nature of the model analysis. At Rough and Ready Island, the flow splits and much of the flow is conveyed to the east in the Stockton Deep Water Ship Channel. More capacity exists in the river at this location, so increasing the capacity with either alternative has a smaller effect. North of Rough and Ready Island, tides can have a large influence on the water surface elevation. Tidal effects should be included in future detailed studies.

10.2.5 Description of Project Impacts

Both alternatives provide substantially increased flood protection for east bank and downstream communities. However, each alternative has its own set of impacts. These impacts are summarized in Table 10-7. The impacts that are not straightforward, such as impacts to native fish populations or effects on land value, are discussed in more detail here.

10.2.5.1 Impacts on Land Use and Land Values

Alternative 1 allows more frequent flooding of the entirety of both Stewart Tract and Roberts Island. With islands flooded to capacity, stored water may reach depths of up to 26 feet. Protection of residential property is therefore not feasible, and residential use of either island is not recommended under this alternative. Stewart Tract is currently zoned such that residential development may be allowed. This characteristic is reflected as a decrease in land value under Alternative 1. The analysis also assumes that the increased frequency of flooding under this alternative would limit the diversity or seasons in which agricultural crops may be produced. This characteristic is reflected as a decrease in land value for both islands.

The creation of 7,040 acres of floodplain from current agricultural land under Alternative 2 clearly decreases the value of that land, but the increased protection provided to the remainder of both islands by the new, and presumably stronger, setback levee is reflected in an increase in land value. The analysis assumes that increased protection from periodic flooding under current conditions will allow an increased confidence in crop safety and therefore allow for production of higher-value, more sensitive crops. On Stewart Tract, the same increase in flood protection should provide for higher land values in case of residential development.

10.2.5.2 Effects on Native Fish

The impacts to aquatic species from creating a flood diversion (Alternative 1) or a floodplain (Alternative 2) depend, in part, on both water quality and habitat conditions in adjacent waters and habitat restoration efforts upstream that may increase native fish populations. In the past, San Joaquin River flows accounted for more than one-fifth of the total freshwater inflow to the Delta.[7] San Joaquin River flows reaching the Delta have declined sharply in recent years, due primarily to increasing diversions upstream; between 2001 and 2005, San Joaquin River flows accounted for only about 10 percent of freshwater inflow to the Delta. This decline in freshwater flow makes the San Joaquin River a less productive habitat for most native fish species. Also, migrating native fish have been impacted by the following: flow reductions in the San Joaquin River that make the river less hospitable (or more difficult for the fish to detect); severely low concentrations of dissolved oxygen in the Stockton Deep Water Ship Channel that may create a barrier to fish migration;[8] and agrochemical inputs from irrigation runoff that make the lower San Joaquin River inhospitable for many aquatic life forms.

Flows through this area may increase in the future, due to changes in diversions, increases in the severity of storms, or decreases in the winter snow pack in San Joaquin River watersheds. Higher flows, including flood flows, may temporarily alleviate low dissolved oxygen conditions and may serve to dilute concentrations of toxic chemicals. Also, depending on when increased flows occur, flood pulses in the lower San Joaquin River may serve to attract spawning migrations of anadromous fish. As a result, flood flows in the San Joaquin River may increase local productivity of aquatic species and increase migratory use of the lower San Joaquin River by anadromous fish species. In addition, restoration projects in the upper San Joaquin River and its major tributaries are intended to increase production of native at-risk species (principally, chinook salmon, steelhead, and green sturgeon); if these projects succeed, more anadromous fish would use the area next to the flood diversion/floodplain project in the future.

Alternative 1

The habitat value offered by the Alternative 1 detention and bypass system would be negligible or negative for aquatic species. Entrainment of fishes in this facility could have a large impact on species that occur in the lower San Joaquin River during the winter and spring, when floods are anticipated (Table 10-8). Entrainment mortality would be affected by the rate and efficiency with which the facility is drained. As the residence times of water on the facility increase, exposure to predators, increased water temperatures, reduced levels of dissolved oxygen, and toxic agricultural chemicals would all contribute to increased mortality. Also, many organisms that do not escape the facility through drainage gates would likely be killed if the facility is pumped dry. Because Stewart Tract and Roberts Island would be used for agricultural production when not flooded, periodic flooding and draining of this area would be expected to contribute agricultural chemicals (dissolved in water and attached to sediments) to adjacent San Joaquin River and

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[7] http://www.iep.water.ca.gov/dayflow.

[8] http://www.sjrdotmdl.org/concept_model.

Delta habitats as it drains. In addition, because the floodwaters detained on the facility would be nearly stagnant, anaerobic conditions might develop, and these conditions are known to promote methylation of mercury into bioavailable forms.

Finally, this facility might create a large amount of habitat for breeding mosquitoes and other disease vectors. When inundated, the facility would create a large standing pool of water; some of the area might remain flooded until active pumping occurs. During this time, mosquito populations could be expected to colonize on the ephemeral habitat provided by the facility and breed in the shallow, warm, still-aquatic habitats that their larvae prefer.

Alternative 2

Alternative 2 calls for accommodating flood flows on floodplain created along the west bank of the San Joaquin River. A range of permanent and ephemeral aquatic habitats would be created under this proposal, including permanent freshwater marsh, tidal freshwater marsh, frequently inundated floodplain (flooding is anticipated in a 3- to 6-year time range), and infrequently inundated floodplain. These habitats provide a range of potential positive and negative impacts for aquatic organisms. The potential for entrainment of aquatic organisms is a potential negative impact on all but the permanent freshwater marsh habitat. Entrainment mortality can be minimized by grading the property to minimize ponding and ensure consistent flows during inundation events.

Non-native species are expected to benefit disproportionately from permanently inundated habitats. In the lower San Joaquin River and southern Delta, such habitats have been colonized by invasive submerged aquatic plant species (submerged aquatic vegetation [SAV]). This vegetation, in turn, supports colonization and persistence of non-native predator species, such as sunfishes and basses (Table 10-9). In areas where SAV does not develop, a permanent freshwater marsh in the lower San Joaquin River may support other predators such as catfish or inland silversides (Table 10-9). Many of these non-native predators are extremely tolerant of the high temperatures, low concentrations of dissolved oxygen, and degraded water quality conditions that persist in the lower San Joaquin River during the dry season; thus, they are perfectly positioned to colonize newly created sub-tidal habitat. Regardless of which predator species become established, their impact on native fish species (including those protected under federal and state law) may be severe.

Native fishes are believed to benefit differentially from ephemerally flooded habitats. Elsewhere in the San Francisco Estuary, tidal marshes, especially those with intricate slough networks, support juvenile rearing of native fish species (e.g., Matern et al. 2002; Visintainer et al. 2006). Floodplain habitats elsewhere in the larger San Francisco Estuary have been shown to support rapid growth for migrating juvenile salmonids (Sommer et al. 2001, 2004, 2005) and native species such as Sacramento splittail make extensive use of floodplain habitat for spawning and rearing. Direct benefits of tidal marshes may include increased primary and secondary productivity, protection from fast currents, and cover from predatory fish that cannot migrate into smaller sloughs and cannot establish a presence in sloughs that drain on the ebb tide.

As inundated floodplains drain, they may produce benefits to native species in downstream aquatic habitats. Inundated floodplains are productive aquatic habitats, and their primary and secondary productivity may be exported to downstream reaches of the estuary. This impact may be particularly important in San Francisco Estuary, which is nutrient-rich but has experienced declines in its already low productivity in recent years (Kimmerer 2004). Furthermore, as floodwaters recede from floodplains, they may carry high loads of sediment and organic matter. These particles increase turbidity, and increased turbidity is expected to retard growth of submerged aquatic vegetation. Some researchers believe that the high clarity of San Joaquin waters (as compared to those of the Sacramento) contribute to increased SAV colonization and non-native predator densities in the lower San Joaquin River and south Delta (Nobriga and Feyrer 2005). If the habitats contemplated in this alternative occasionally increase turbidity in the lower San Joaquin River and south Delta, they may help to counteract invasion by non-native SAV and fish predators such as sunfishes and basses in the family Centrarchidae.

10.2.5.3 Effects on Other Wildlife

The floodplain that would be created by Alternative 2 along the west bank of the San Joaquin River provides an excellent opportunity to create habitat in accordance with the CALFED Bay-Delta Ecosystem Restoration Program Plan. Proposed restoration goals include “more natural channel configuration with greater amounts of slough and permanent and seasonal wetland habitats (floodplain, riparian, emergent freshwater wetland, tidal wetland) that would provide more habitat for fish, waterfowl, and wildlife, and improved aquatic foodweb production and water quality” (Sacramento–San Joaquin Delta Ecological Management Zone [BDCP 2000]).

Alternative 2 has the potential to meet these goals. The elevation of the proposed floodplain slopes from about 15 feet (NAVD88) upriver at the south end of Stewart Tract to about -10 feet downriver at the north end of Roberts Island (Figure 10-5). Tidal range in this section of river is about 2 feet, with mean higher high water at 0.71 feet. The combination of freshwater tidal influence and elevation change along the setback area allows for the creation of a range of habitats. These habitats will be graded along an approximate north to south gradient and will include permanent freshwater marsh, tidal freshwater marsh, frequently inundated floodplain, and infrequently inundated floodplain. Floodplain areas will also be managed along an east/west gradient as riparian areas with trees grading to upland scrub habitat without trees. A California Natural Diversity Database search of the project area and surrounding quads indicates that the area may contain 27 listed species (Table 10-8), including the federally and state endangered riparian brush rabbit. Scrub plantings on the setback levee would allow riparian areas to be designed as habitat for the riparian brush rabbit, which requires continuous scrub cover from lowland riparian areas to upland refuge areas in times of flood. Alternatively or concurrently, upriver floodplain might be managed for any of the other endangered, threatened, or sensitive species listed in Table 10-8. A detailed examination of the floodplain habitats and the impacts of the alternative on them is outside the scope of this report.

This floodplain may be managed as parkland, providing recreational activities from hiking and picnicking to boating, fishing, or hunting. In the southern reaches, the floodplain may be managed either as frequently flooded agricultural land, public land, or as a mix of agricultural and public land.

10.3 COST ESTIMATE

The detailed cost estimate for Alternatives 1 and 2 is presented in Table 10-10. Estimated material quantities and unit costs for the materials are also presented in Table 10-10. The key assumptions of the cost estimate and the basis used in developing the cost estimate are listed below.

1. Add-on costs for the two alternatives were assumed to be 30 percent for contingencies, 10 percent for administration, 8 percent for engineering, and 12 percent for construction management. Construction costs include a 10 percent allowance for contractor mobilization and de-mobilization.
2. It was assumed that on-site material would be used for construction of the Alternative 2 levees.
3. The cost of purchasing land on Stewart Tract and Roberts Island was assumed to be $100,000 and $12,500 per acre, respectively, for Alternative 2. For Alternative 1, it was assumed that a flood easement for the currently developable land on Stewart Tract would cost the purchase price ($100,000 per acre) minus 20 percent of the purchase price for agricultural land ($12,500 per acre). It was assumed that flood easements for the predominantly agricultural land of Roberts Island would cost 80 percent of the purchase price (80 percent of $12,500).
4. Land costs for both developable land and non-developable agricultural land were obtained from a relevant website.[9] The costs obtained from this source for the Stewart Tract land were reduced to reflect the fact that the land, though potentially available for development, requires significant infrastructure input and permits.
5. It was assumed that a 0.5-mile-long causeway would be needed under Alternative 1 to allow flows diverted from San Joaquin River to pass under Interstate Highway 5.
6. It was assumed under Alternative 1 that the at-grade State Route 4 and major and minor roads would be allowed to flood during major events that flood Roberts Island.
7. It was assumed that the existing 22 miles of San Joaquin River levee to be removed under Alternative 2 are, on average, 25 feet high, have bank slopes of 2.5 horizontal to 1 vertical, and a 25-foot-wide crest. It is further assumed that the material can be used to construct the new levee 0.5 mile to the west.

The estimated cost of Alternative 1 is $1.9 billion, and the estimated cost of Alternative 2 is $1.2 billion.

10.4 FINDINGS AND CONCLUSIONS

10.4.1 Risk Reduction Estimate

Construction of either Alternative 1 or Alternative 2 would result in a decrease in the water surface elevations in the San Joaquin River between Lathrop and Stockton. The decrease for a large storm event, such as the January 1997 event, the largest on record at Vernalis, could be on the order of 10 feet in the vicinity of Mossdale. Tables 10-3 and 10-4 show the different flood stages at Vernalis and Mossdale. For a large storm event, a reduction in the water surface elevation on the order of 10 feet would result in a change in flood stage from Moderate Flood

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[9] http://homes.realtor.com/map/search/searchresults.aspx?mindt=1%2f1%2f0001+12%3a00%3a00+AM&maxdt=12%2f31%2f9999+11%3a59%3a59+PM&source=a15696&ctid=94664&ml=3&typ=20&sid=7a0efa28d0c144de9ed5b7ade1470bf6&pg=1.

Stage (32.1–33.1 feet at Mossdale Station) to Action Level Stage (19.5–28.5 feet at Mossdale Station). Along the western edge of Rough and Ready Island, a reduction on the order of 3 to 5 feet would occur.

Although both the east and west banks of the river would enjoy higher levels of protection, the new setback levee on the west bank would be built to a higher standard than the existing east bank levee and, unless provisions are incorporated into the design, would tend to result in failure of the east bank levee before the west bank levee.

A reduction in the peak water surface elevations on the order predicted in this analysis corresponds to reduction by a factor of 10 or more[10] in the frequency of levee failures along the San Joaquin River (on Stewart Tract, Roberts Island, and Rough and Ready Island). Therefore, in addition to providing increased flood protection to towns along the San Joaquin River (which were not explicitly evaluated in Phase 1 of the Delta Risk Management Strategy project), a significant risk reduction would result for islands in the Delta that were considered in the Phase 1 analysis.

10.4.2 Conclusions and Recommendations

As discussed in Section 10.2 and shown in Table 10-6, Alternative 2 provides more benefits and fewer adverse effects to social systems, agricultural land use, infrastructure, land values, and habitat than Alternative 1. Section 10.3 shows that Alternative 2 will cost less than Alternative 1 ($1.2 billion versus $1.9 billion, respectively). Section 10.4 shows that both projects provide substantial flood control to the populated areas east of San Joaquin River between Lathrop and Stockton. Alternative 2 also provides improved flood protection to the majority of Stewart Tract and Roberts Island. For these reasons, we recommend Alternative 2 for more detailed analysis and planning.

[10] This reduction corresponds to the change in the frequency of flood levels with potential to cause levee failure. A reduction in the frequency of failure associated with the construction of new levees (which will have higher capacity and lower probability of failure) is not considered, because not all levees along the San Joaquin River are upgraded.

Tables

Table 10-1 Current Linear Infrastructure

San Joaquin Bypass (miles of linear utilities)	Minor Roads	Major Roads	Highways	Railway	Transmission Lines	Gas/Water/ Petroleum Pipelines
Upper Roberts Island	26.6	0.0	0.0	0.0	11.5	4.1
Roberts Island	58.4	5.2	8.5	5.2	31.5	31.0
Stewart Tract	11.7	--	1.4	0.9	5.5	--

Table 10-2 Current Nonlinear Infrastructure

San Joaquin Bypass (counts of non-linear utilities)	Substations Solid Waste	Hwy Bridge	Oil and Gas Wells	Gas Fields (in acres)	Dwellings - Family	Dwellings Other	Commercial & Industrial	Other
Upper Roberts Island	0	1	50	1,278	48	4	--	1
Roberts Island	1	2	119	3142	146	52	3	5
Stewart Tract	--	6	7	--	62	14	2	

Table 10-3 San Joaquin River Flood Stages

Flood Categories	Vernalis feet	Vernalis flows (cfs)	Mossdale feet	Mossdale flows (cfs)
Major flood stage:	37.3	Data unavailable	33.1	Data unavailable
Moderate flood stage:	32	50,000	32.1	
Flood stage:	29	35,000	28.5	50,000
Action stage:	24.5	22,000	19.5	26,000
Below action stage				

cfs = cubic feet per second

Table 10-4 San Joaquin River Historical Crests at Vernalis Station

Date	Feet
4/13/2006	29.25
1/5/1997	34.88
3/18/1986	29.8
1/6/1984	29
4/18/1982	29.12
1/27/1969	34.55
12/9/1950	32.81
4/2/1940	30.43
3/16/1938	32.71
2/12/1938	32.11

Table 10-5 Bypass Detention Capacities

Bypass Detention Capacities in acre-feet	
South Stewart Tract	8,257
North Stewart Tract	39,186
Upper Roberts Island	76,891
Middle and Lower Roberts	292,984
Total Detention	**417,318**

Table 10-6 Water Surface Elevations, January 1997 Flood

River Mile	Description	Existing Conditions	Alternative 1: Detention and Bypass		Alternative 2: Setback Levee	
		Water Surface Elevation (feet, NAVD88)	Water Surface Elevation (feet, NAVD88)	Decrease in Water Surface Elevation (feet)	Water Surface Elevation (feet, NAVD88)	Decrease in Water Surface Elevation (feet)
50.31	South Stewart Track	30.27	30.45	-0.18	24.7	5.57
48.15	North Stewart Tract	30.03	26.18	3.85	22.89	7.14
41.62	Upper Roberts Island	28.39	18.34	10.05	18.05	10.34
36.33	Middle Roberts Island	23.27	10.7	12.57	13.08	10.19
34.58	Mossdale	12.67	6.84	5.83	9.58	3.09
34.56	Rough and Ready Island A	12.67	7.06	5.61	9.73	2.94
34	Rough and Ready Island B	12.65	6.91	5.74	9.49	3.16
32.85	Rough and Ready Island C	12.63	6.77	5.86	9.28	3.35
31.72	North of Rough and Ready Island	12.59	6.47	6.12	8.77	3.82
31.26	Lower Roberts Island	10.58	6.28	4.3	8.17	2.41
30.68		10.6	6.25	4.35	8	2.6
29.36		9.47	6.18	3.29	7.86	1.61
26.93	Lower Roberts Island	8.06	6.1	1.96	7.72	0.34
24.65	McDonald Island	7.1	6.05	1.05	6.75	0.35
17.53	Downstream Boundary	6	6	0	6	0

NAVD88 = North American Vertical Datum of 1988

Table 10-7 Summary of Project Impacts

Impact	Alternative 1: Detain and Bypass	Alternative 2: River Widening
Effects on Residential and Recreational Use		
Number of family dwellings relocated	145	0-3
Number of other structures relocated	51	0-2
Potential recreational parkland created	None	7,040 acres
Effects on Agriculture		
More frequent flooding	37,275 acres	3,520 acres
Permanent loss	0 acres	3,520 acres
Increased flood protection	0 acres	30,235 acres
Interrupted agricultural preservation (land which can't be used for anything other than agricultural purposes, as it is subject to occasional flooding)	37,275 acres	3,520 acres (in non-marsh regular floodplain. May be flooded annually)
Effect on crop diversity	Crop choice and growing season may be limited by occasional flooding	Crop choice is not flood-limited, as most land will retain 100+ year flood protection
Effects on Infrastructure		
Permanently flooded oil or gas wells	None	5-10 in tidal marsh floodplain
Oil or gas wells with increased flood protection	None	170-175
Occasionally flooded oil or gas wells	180	Approx. 5 in upland floodplain
Miles of utility subjected to increased flood occurrence:		
minor roads	97	0
major roads	5	0
highways	7	0
rail	9	0
Effects on Land Value		
Change in land value	Decreased value: 37,275 acres	Increased value: 30,235 acres, decreased value: 7,040 acres
Land available for residential development	None	4,500 acres
Effects on Habitat and Sensitive Species		
Potential land for managed wetland or tidal marsh	Minor, not included in plan	3,520 acres in lower elevation floodplain
Potential for floodplain habitat	Poor habitat quality	3,520 acres in higher elevation floodplain
Total potential new wetland habitat	None	7,040 acres, total floodplain
Potential new spawning habitat for native fish	Poor quality	High quality
Potential habitat for sensitive riparian wildlife	Minor, not included in plan	3,520 in higher elevation floodplain

Table 10-8 Special-Status Species Potentially Affected by Alternatives 1 or 2

Species name	Common Name	Federal Status	California Status	California Dept. of Fish and Game Status	California Native Plant Society Status	General Habitat
Acipenser medirostrus	Green sturgeon	T	T	--	--	May use lower San Joaquin River as a migration corridor. Forage in slow-moving backwaters
Buteo swainsoni	Swainson's hawk	--	T	--	--	(Nesting) Breeds in stands with few trees in juniper-sage flats, riparian areas and in oak savannah
Carex comosa	Bristly sedge	--	--	--	2.1	Marshes and swamps
Cirsium crassicaule	Slough thistle	--	--	--	1B.1	Chenopod scrub, marshes and swamps, riparian scrub
Coccyzus americanus occidentalis	Western yellow-billed cuckoo	C	E	--	--	(Nesting) Riparian forest nester, along the broad, lower flood-bottoms of larger river systems
Emys = (Clemmys) marmorata	Western pond turtle	--	--	Special Concern		A thoroughly aquatic turtle of ponds, marshes, rivers, streams and irrigation ditches with aquatic vegetation
Eremophila alpestris actia	California horned lark	--	--	Special Concern	--	Coastal regions, chiefly from Sonoma Co. to San Diego Co. Also main part of San Joaquin valley and east to foothills
Eryngium racemosum	Delta button-celery	--	E	--	1B.1	Riparian scrub
Hibiscus lasiocarpus	Rose-mallow	--	--	--	2.2	Marshes and swamps (freshwater)
Hypomesus transpacificus	Delta smelt	T	T	--	--	Spawning may occur upstream of Mossdale. May become entrained in floodplains. Larvae may benefit from sub-tidal sloughs. Smelt lower in estuary may benefit from food exported from floodplain.
Laterallus jamaicensis coturniculus	California black rail	--	T	--	--	Mainly inhabits salt-marshes bordering larger bays
Lathyrus jepsonii var. *jepsonii*	Delta tule pea	--	--	--	1B.2	Freshwater and brackish marshes
Lilaeopsis masonii	Mason's lilaeopsis	--	R	--	1B.1	Freshwater and brackish marshes, riparian scrub
Limosella subulata	Delta mudwort	--	--	--	2.1	Riparian scrub, freshwater marsh, brackish marsh. Probably the rarest of the suite of delta rare plants

Table 10-8 Special-Status Species Potentially Affected by Alternatives 1 or 2

Species name	Common Name	Federal Status	California Status	California Dept. of Fish and Game Status	California Native Plant Society Status	General Habitat
Neotoma fuscipes riparia	Riparian = (San Joaquin Valley) woodrat	E	--	Special Concern	--	Riparian areas along the San Joaquin, Stanislaus and Tuolumne rivers
Oncorhynchus mykiss	Steelhead	T	--	--	--	Use lower San Joaquin River as a migration corridor; out-migrating adults and juveniles may rear or become entrained in ephemeral habitats.
Oncorhynchus tshawytscha	Chinook salmon fall-run	ESA listing candidate	--	Special Concern	--	Use lower San Joaquin River as a migration corridor; juveniles may rear or become entrained in ephemeral habitats.
Oncorhynchus tshawytscha	Chinook salmon late-fall run	ESA listing candidate	--	Special Concern	--	Use lower San Joaquin River as a migration corridor; juveniles may rear or become entrained in ephemeral habitats.
Oncorhynchus tshawytscha	Chinook salmon spring-run	T	T	--	--	Currently not found in the San Joaquin River; however, this basin used to be more productive than Sacramento. Restoration into San Joaquin River tributaries possible. Juvenile fish may rear or become entrained in bypass/detention basin habitat.
Pogonichthys macrolepiditus	Sacramento splittail	--	--	Special Concern	--	Spawn and rear in floodplain habitats, migration through lower San Joaquin River corridor to and from spawning grounds
Potamogeton zosteriformis	Eel-grass pondweed	--	--	--	2.2	Marshes and swamps
Rana aurora draytonii	California red-legged frog	T	--	Special Concern	--	Lowlands and foothills in or near permanent sources of deep water with dense, shrubby or emergent riparian vegetation
Sagittaria sanfordii	Sanford's arrowhead	--	--	--	1B.2	Marshes and swamps
Scutellaria galericulata	Marsh skullcap	--	--	--	2.2	Marshes and swamps, lower montane coniferous forest, meadows and seeps

Table 10-8 Special-Status Species Potentially Affected by Alternatives 1 or 2

Species name	Common Name	Federal Status	California Status	California Dept. of Fish and Game Status	California Native Plant Society Status	General Habitat
Sylvilagus bachmani riparius	Riparian brush rabbit	E	E	--	--	Riparian areas on the San Joaquin River in northern Stanislaus County.
Thamnophis gigas	Giant garter snake	T	T	--	--	Prefers freshwater marsh and low gradient streams; has adapted to drainage canals and irrigation ditches
Trichocoronis wrightii var. *wrightii*	Wright's trichocoronis	--	--	--	2.1	Marshes and swamps, riparian forest, meadows and seeps, vernal pools

C = Candidate
E = Endangered
R = Rare
T = Threatened

Table 10-9 Invasive Fish Species

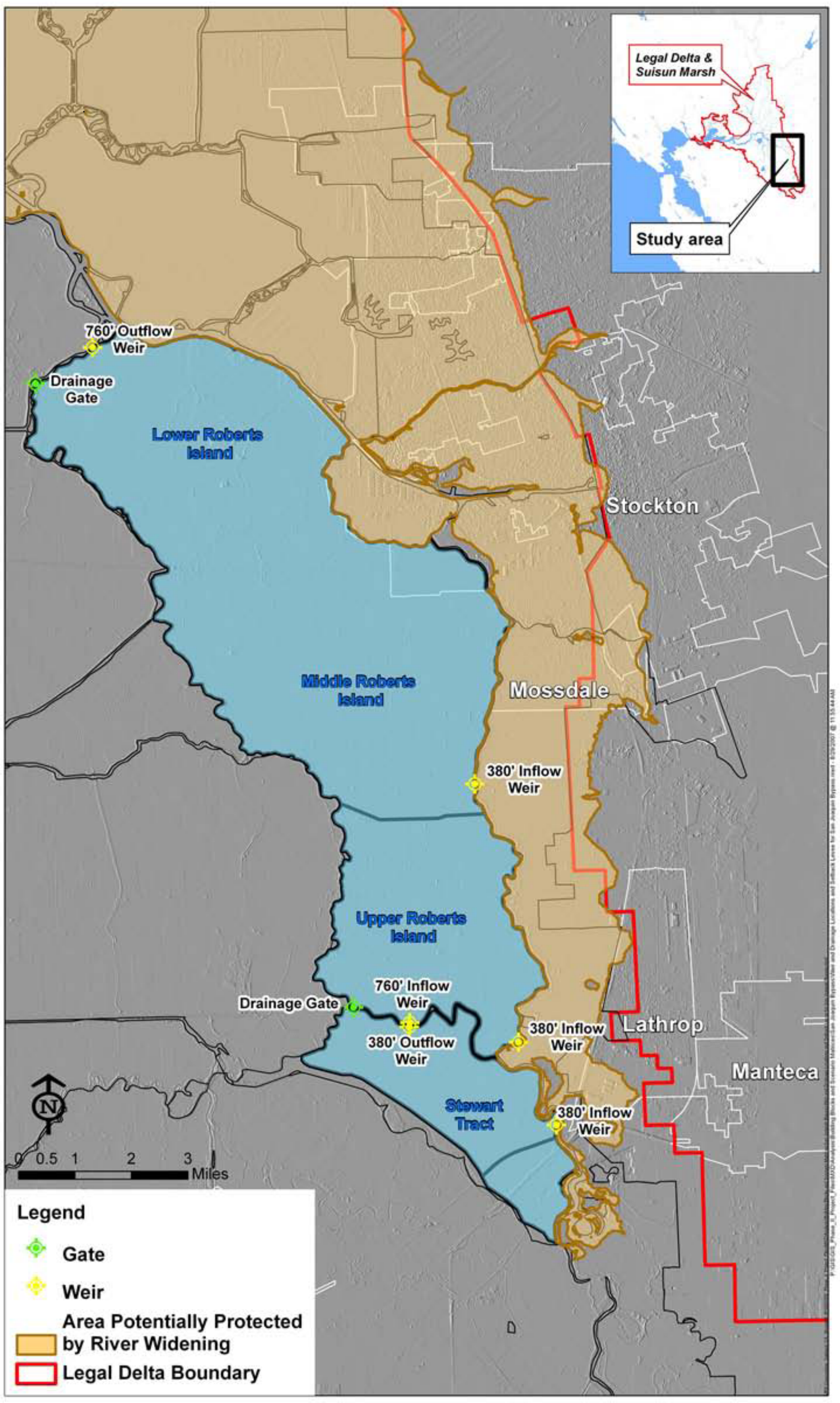
Latin	Common	Habitat
Micropterus punctulatus	Spotted bass	Prefer slower, more turbid water than smallmouth bass and higher flows than largemouth bass; mostly occur in reservoirs
Menidia beryllina	Inland silverside	Highly invasive. Form vast schools (shoals) along shallow, unvegetated shorelines; prefer warm water
Ameiurus nubulosa	Brown bullhead	Prefer slow-moving, warm, turbid waters and highly altered stretches of river, weedy sloughs; tolerant of very high temperatures and very low dissolved oxygen.
Gambusia affinis	Mosquito fish	Specialize in still waters and disturbed habitats such as occur on a floodplain; tolerant of high temperatures and low, dissolved oxygen
Alosa sapidissima	American shad	Adults and juveniles use lower San Joaquin River as a migratory corridor. Juveniles rear in lower SJR and are susceptible to entrainment.
Ameiurus catus	White catfish	Specialize in warm, slow-moving low elevation waterways
Ictaluraus punctatus	Channel catfish	Prefer fast-moving, clear, warm waters; floodplain habitat is not optimal
Morone saxitalis	Striped bass	Spawn in rivers from April. Flooding concurrent with spawning may reduce survival; pelagic predators not expected to perform well on a floodplain or in tidal marsh
Pomoxis nigromaculatis	Black crappie	Warm, slow-moving waters; tolerant of extreme temperatures
Lepomis gulosus	Warmouth	Warm, slow-moving waters; tolerant of high temperatures
Lepomis macrochirus	Bluegill	Warm, slow-moving waters; tolerant of high temperatures
Micropterus salmoides	Largemouth bass	Warm, shallow water with relatively dense SAV
Pomoxis annularis	White crappie	Warm, turbid river backwaters. Spawn in shallow waters by building nests in clay; usually associated with overhanging vegetation
Lepomis microlophus	Redear sunfish	Warm, slow-moving waters, especially those with SAV; tolerant of high temperatures
Lepomis gibbosus	Pumpkinseed	Warm, slow-moving waters, especially those with SAV
Lepomis cyanellus	Green sunfish	Warm, slow-moving waters, especially those with SAV
Dorosoma petenense	Threadfin shad	Freshwater, warm, sluggish backwaters of rivers
Notemigonius crysoleucas	Golden shiner	Warm shallow ponds and sloughs with aquatic vegetation; tolerant of high temperatures and low, dissolved oxygen
Cyprinus carpio	Common carp	Specialize in warm, slow-moving, oxygen-deficient waterways with abundant SAV
Carassius auratus	Goldfish	Warm, slow-moving, oxygen-deficient waterways with abundant SAV
Pimephales promelas	Fathead minnow	Tolerant of highly degraded water-quality conditions, including high turbidity, organic matter, and low, dissolved oxygen
Cyprinella lutrensis	Red shiner	Thrive in unstable, intermittent, and disturbed environments. Extremely tolerant of high temperatures and low dissolved oxygen conditions
Ameiurus melas	Black bullhead	Prefer slow-moving, warm, turbid waters and highly altered stretches of river; tolerant of very high temperatures and very low, dissolved oxygen
Percina macrolepida	Bigscale logperch	Slow-moving, warm, clear streams over mud, gravel, rocks, or woody debris; larvae drift and expected to survive well in floodplains

SAV = submerged aquatic vegetation

Table 10-10 Cost Estimates

Item	Unit	Alternative 1: Detention and Bypass			Alternative 2: River Widening		
		Quantity	Unit Cost	Cost/$million	Quantity	Unit Cost	Cost/$million
Flood Protection:							
Land (Alt. 1 easements, Alt. 2 purchase)							
Stewart Tract	acre	5,684	$97,500	$554.2	1,184	$100,000	$118.4
Roberts Island	acre	31,591	$10,000	$315.9	5,856	$12,500	$73.2
Infrastructure:							
Highway 5 Bridge (110 feet wide,	square-foot	290,400	$250	$72.6	290,400	$250	$72.6
Highway 4 Bridge (40 feet wide, 0	square-foot	---	---	---	105,600	$250	$26.4
Major Roads	mile	---	---	---	3	$1,000,000	$3.0
Major Road Bridges (Rough & Re	square-foot	---	---	---	211,200	$250	$52.8
Minor Roads	mile	---	---	---	3	$500,000	$1.5
Railroads	square-foot	66,000	$250	$16.5	198,000	$250	$49.5
Relocations							
Family Dwellings	dwelling	145	$500,000	$72.5	3	$500,000	$1.5
Other Structures	structure	51	$200,000	$10.2	2	$200,000	$0.4
Levee Construction (local material ass	mile	---	---	---	22	$10,000,000	$220.0
Removal of Existing Levees	CY	---	---	---	9,411,111	$3	$28.2
Diversion Weirs (6 @ 1000 feet each)	feet	6,000	$10,000	$60.0	---	---	---
Flood Gates	gate	2	$100,000	$0.2	---	---	---
Environmental Enhancement:							
Grade Floodplain For Drainage	acres	---	---	---	3,570	$5,000	$17.9
Levee vegetation	mile	0	$1,440,000	$0.0	22	$1,440,000	$31.7
Monitoring & Baseline Data Colle	LS	1	$100,000	$0.1	1	$100,000	$0.1
Subtotal				**$1,102.2**			**$697.2**
Mob & Demob	percent	10%		$110.2	10%		$69.7
Subtotal				$1,212.4			$766.9
Contingenices	percent	30%		$363.7	30%		$230.1
Subtotal - Construction Cost				$1,465.9			$927.2
Administration	percent	10%		$146.6	10%		$92.7
Engineering	percent	8%		$117.3	8%		$74.2
Construction Management	percent	12%		$175.9	12%		$111.3
Subtotal - Construction Cost & Add-ons				$1,905.7			$1,205.4
Escalation to mid-2007	percent	0%		$0.0	0%		$0.0
Total Cost				**$1,905.7**			**$1,205.4**

Figures



Weir and Drainage Locations
San Joaquin Bypass

San Joaquin Detention & Bypass Building Block:

Low-level weirs would be placed in the west bank levees of the San Joaquin River between Lathrop and Stockton. These weirs would direct excess floodwater out of San Joaquin River into Stewart Tract or if necessary, into both Stewart Tract and Roberts Island. The diverted flood water would be detained until the flood has passed or, once the storage capacity of the islands is approached, released via weirs that direct the flow away from developed areas.

Objective:
To protect lives and property in Lathrop, Mossdale, Stockton, and adjacent communities from extreme flood events

Project Criteria:

- Project must provide substantially increased flood protection to east bank communities.
- Project should maximize potential environmental benefits.
- Land ownership would not be considered in the initial identification of project location.

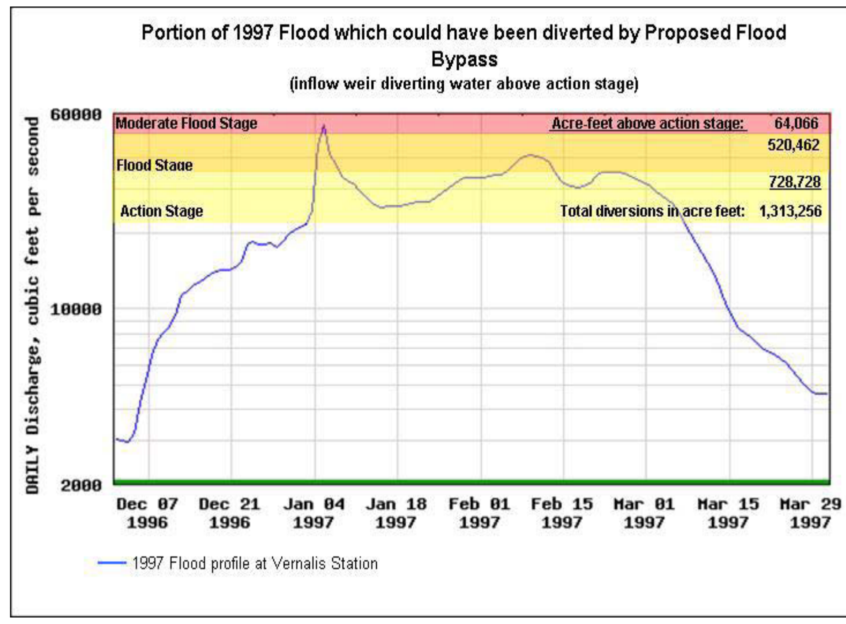
Benefits

- Eases strain of both upstream and downstream levees to reduce failure during flood events
- Preserves existing agricultural lands

Additional Consequences

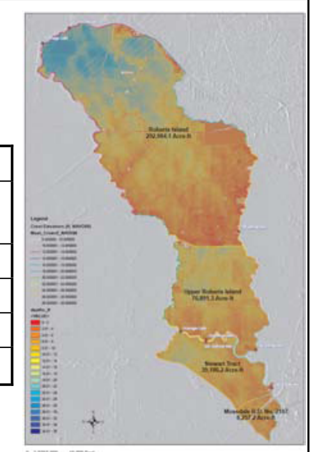
- Current dwellings would be relocated off affected islands.
- Current agricultural lands and utilities on affected islands would be subject to flooding at an increased frequency compared to current conditions.

Flood Volumes Channeled Through Bypass System:



Detention Capacity of Stewart Tract and Roberts Island

Island	acre-feet
Lower and Middle Roberts Island	292,984
Upper Roberts Island	76,891
Stewart Tract	39,186
South Stewart Tract	8,257
Total Capacity	**417,318**



San Joaquin Setback Levee Statistics:

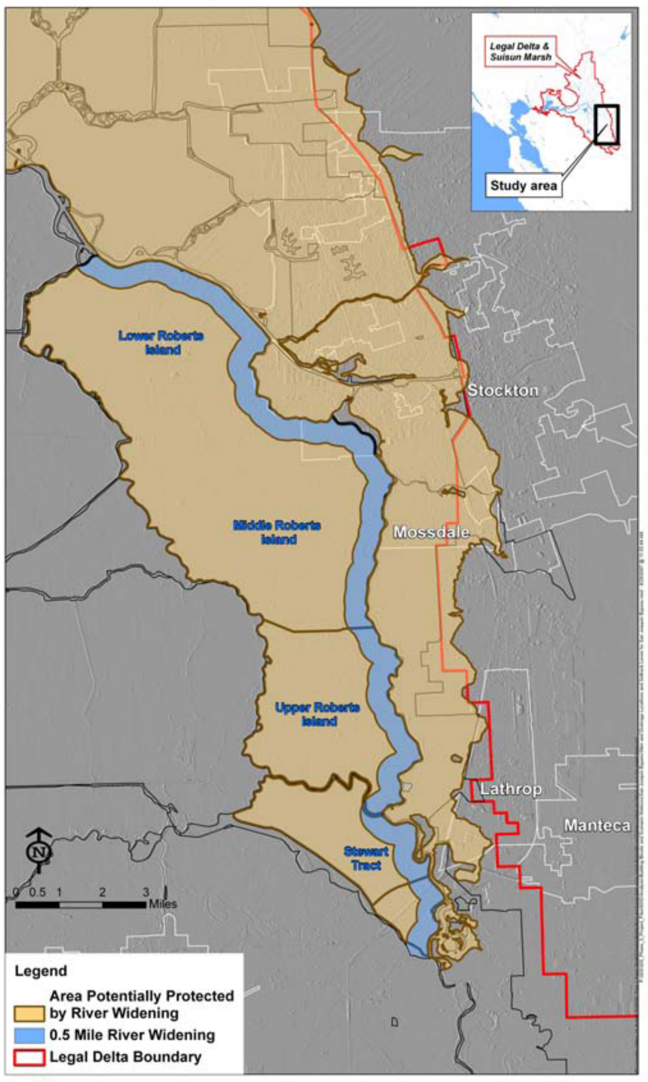
Flood Activity on the San Joaquin River:
San Joaquin River discharge data are available from 1923 through 2007[1]. During those 84 years:

- The river has exceeded the flood stage 10 times (once every 8.34 years on average).
- The river exceeds moderate flood stage every 16.8 years on average, or 5 times.
- Stewart Tract has breached and flooded 3 times, on average every 28 years. This flooding has eased strain on other levees and protects vulnerable neighborhoods.

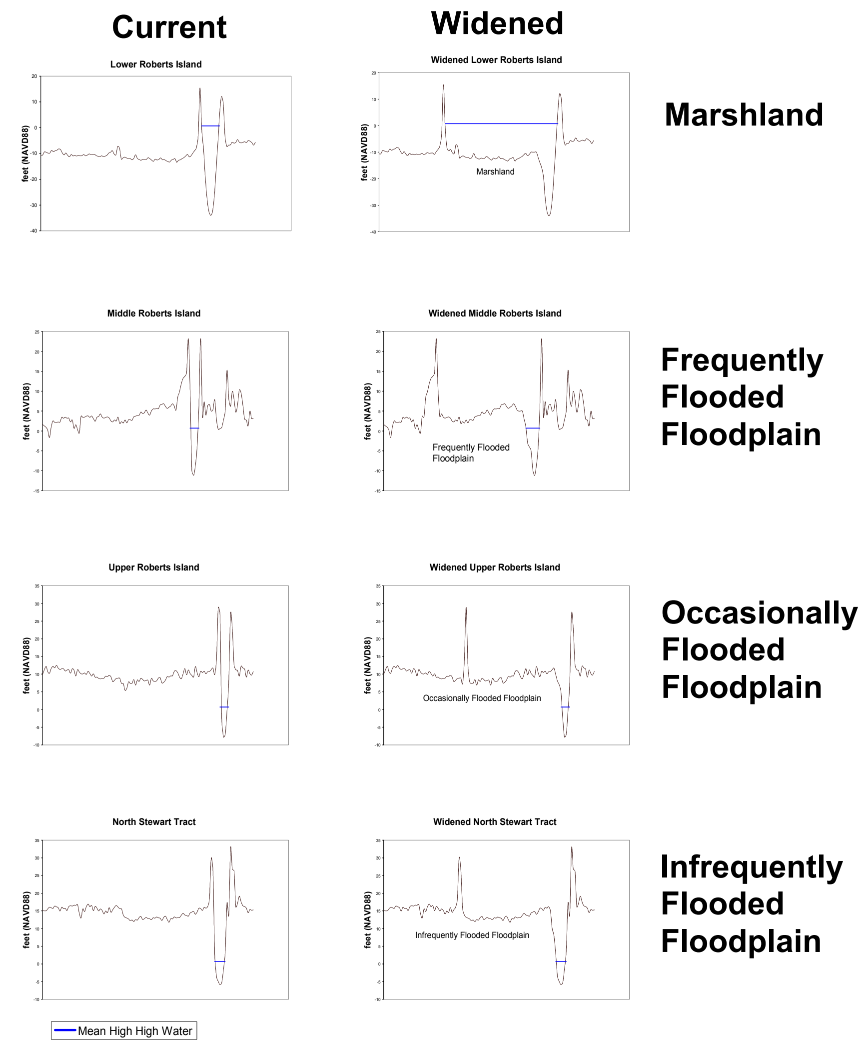
Project Impacts	
Effects on Residential Use	196 dwellings relocated
Effects on Agriculture:	
Agriculture with increased flood risk	37,275 acres
Permanent Loss of Agricultural Land	0 acres
Acres preserved as permanently agricultural	37,275 acres
Effects on Infrastructure:	
oil or gas wells with increased flood risk	180
utilities with increased flood risk:	
minor roads	97 miles
major roads	5 miles
highways	7 miles
rail	9 miles
Effects on Land Value	decreased for all 37,275 acres
Effects on Habitat and Sensitive Species	poor habitat quality, minor effects
Project Cost	**$1.9B**

[1] Data available at http://waterdata.usgs.gov

Setback Levee
San Joaquin River



Comparison of Current to Widened Cross Sections



San Joaquin Setback Levee Building Block:

A setback levee would be built about 0.5 mile inland of current levees along the San Joaquin River shoreline of both Stewart Tract and Roberts Island, creating a 0.5-mile-wide, 22-mile-long floodplain. This alternative would greatly increase the capacity of this stretch of river during flood events and provide substantial habitat and recreational benefits at other times. The setback levee project would provide flood protection to developed and urban areas on the east bank, as well as to agricultural lands on both islands.

Objectives

- Protect lives and property in Lathrop, Mossdale, Stockton, and adjacent communities from extreme flood events.
- Protect agriculture and property on Stewart Tract and Roberts Island from flood events.
- Restore critical marshland, floodplain, and riparian habitats along the San Joaquin River.

Project Criteria:

- Project must provide substantially increased flood protection to east bank communities.
- Project should maximize environmental benefits.

Benefits

- Eases strain on existing levees to reduce failure potential during flood events.
- Protects both east bank and west bank lands from flooding.
- Provides substantial environmental benefits to fish and wildlife.
- Provides increased recreational opportunities along San Joaquin River.

Additional Consequences

- Approximately 7,040 acres of agricultural land would be removed from agricultural use.

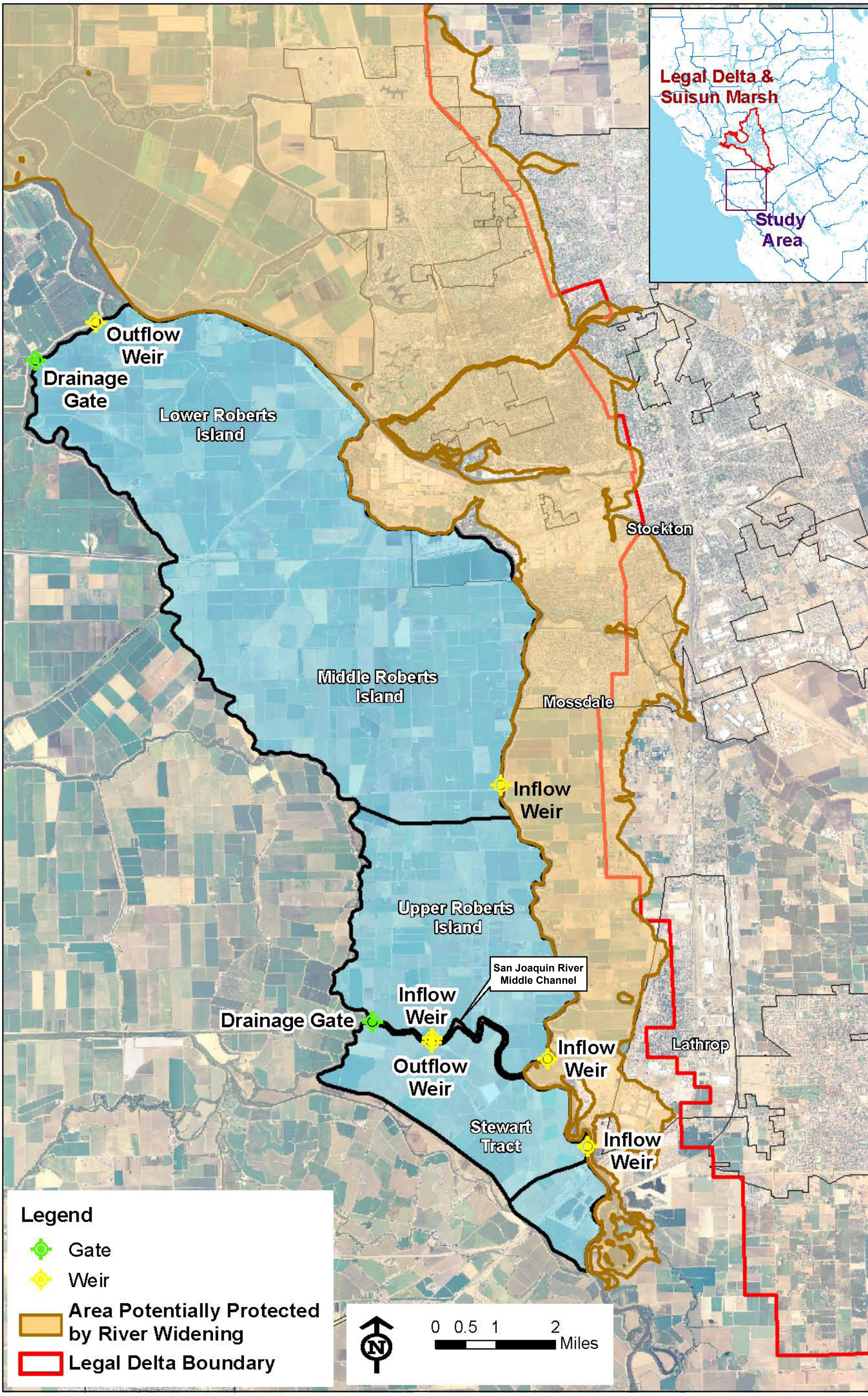
San Joaquin Setback Levee Statistics:

Flood Activity on the San Joaquin River:
San Joaquin River discharge data are available from 1923 through 2007.[1] During those 84 years:

- The river has exceeded the flood stage 10 times (once every 8.34 years on average).
- The river exceeds moderate flood stage every 16.8 years on average, or 5 times.
- Stewart Tract has breached and flooded 3 times, on average every 28 years. This flooding has eased strain on other levees and protects vulnerable neighborhoods.

Project Impacts	
Effects on Residential Use	<15 dwellings relocated
Potential parkland created	7,040 acres
Effects on Agriculture:	
More Frequent Flooding	3,520 acres
Permanent Loss	3,520 acres
Increased Flood Protection	30,235 acres
Effects on Infrastructure:	
Permanently flooded oil or gas wells	5-10 in tidal marsh floodplain
occasionally flooded oil or gas wells	5-10 in upland floodplain
oil or gas wells with increased flood protection	170-175
miles of road or railway subject to increased flood risk	none
Effects on Land Value:	
Increased	30,235 acres
Decreased	7,040 acres
Land available for residential development	4,500 acres
Effects on Habitat and Sensitive Species:	
Total potential new floodplain	7,040 acres, total floodplain
Potential land for managed wetland or tidal marsh	3,520 acres
Project Cost	$1.2B

[1]Data available at http://waterdata.usgs.gov



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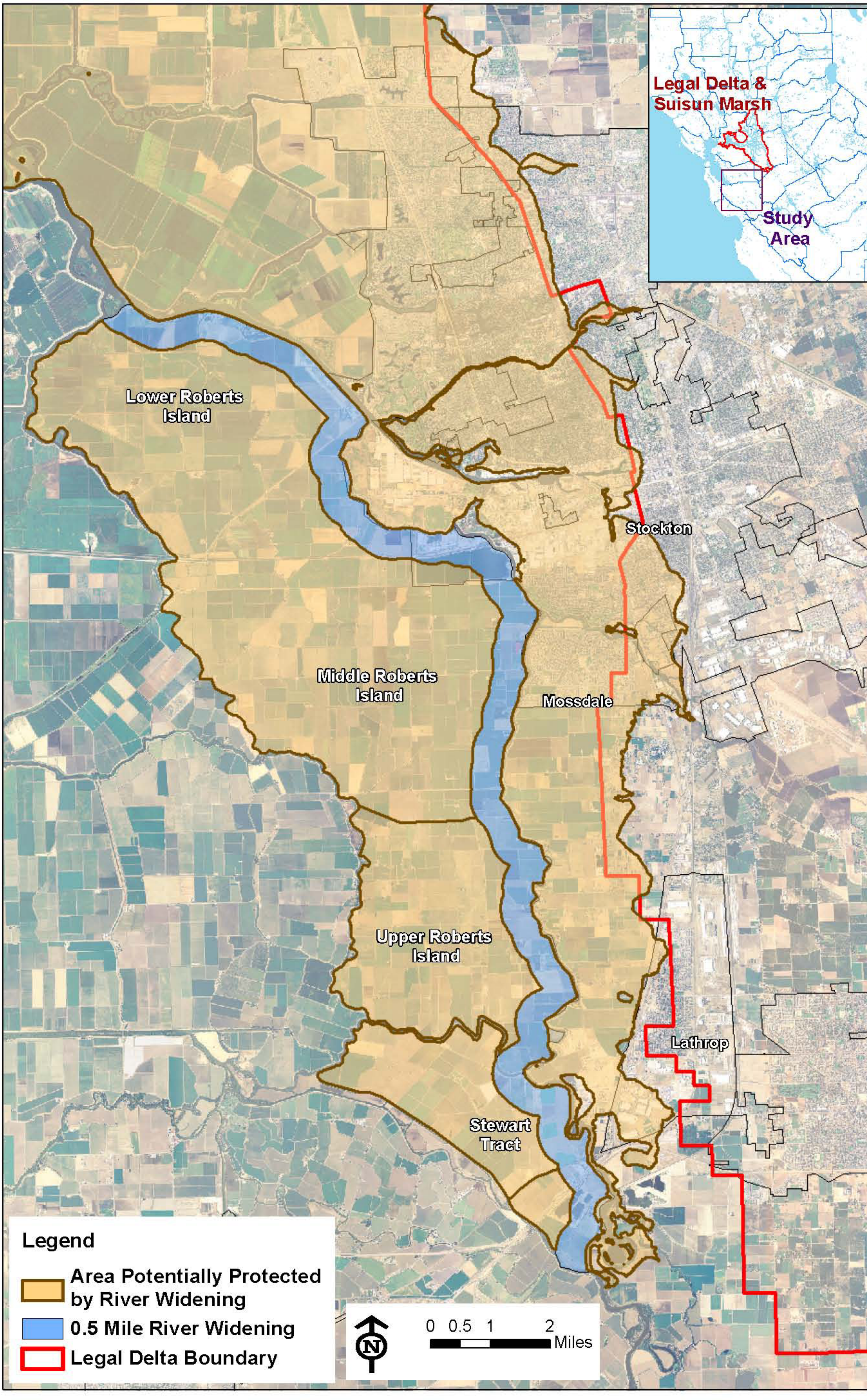
Delta Risk Management Strategy (DRMS)
Phase 2

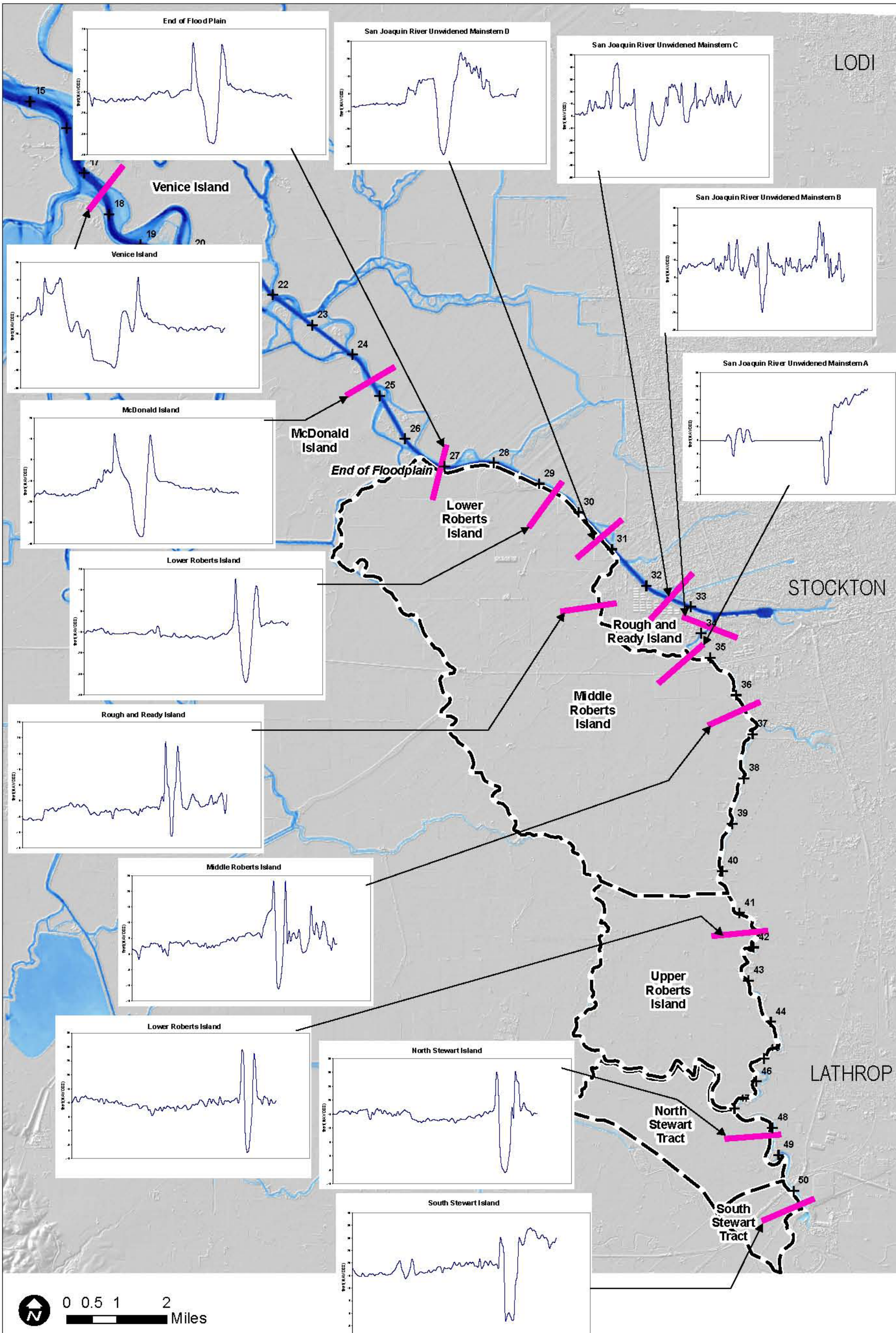
SAN JOAQUIN BYPASS: ALTERNATIVE 1, DETENTION AND BYPASS

Figure
10-3



SAN JOAQUIN BYPASS: ALTERNATIVE 2, 0.5-MILE WIDENING

Figure 10-4

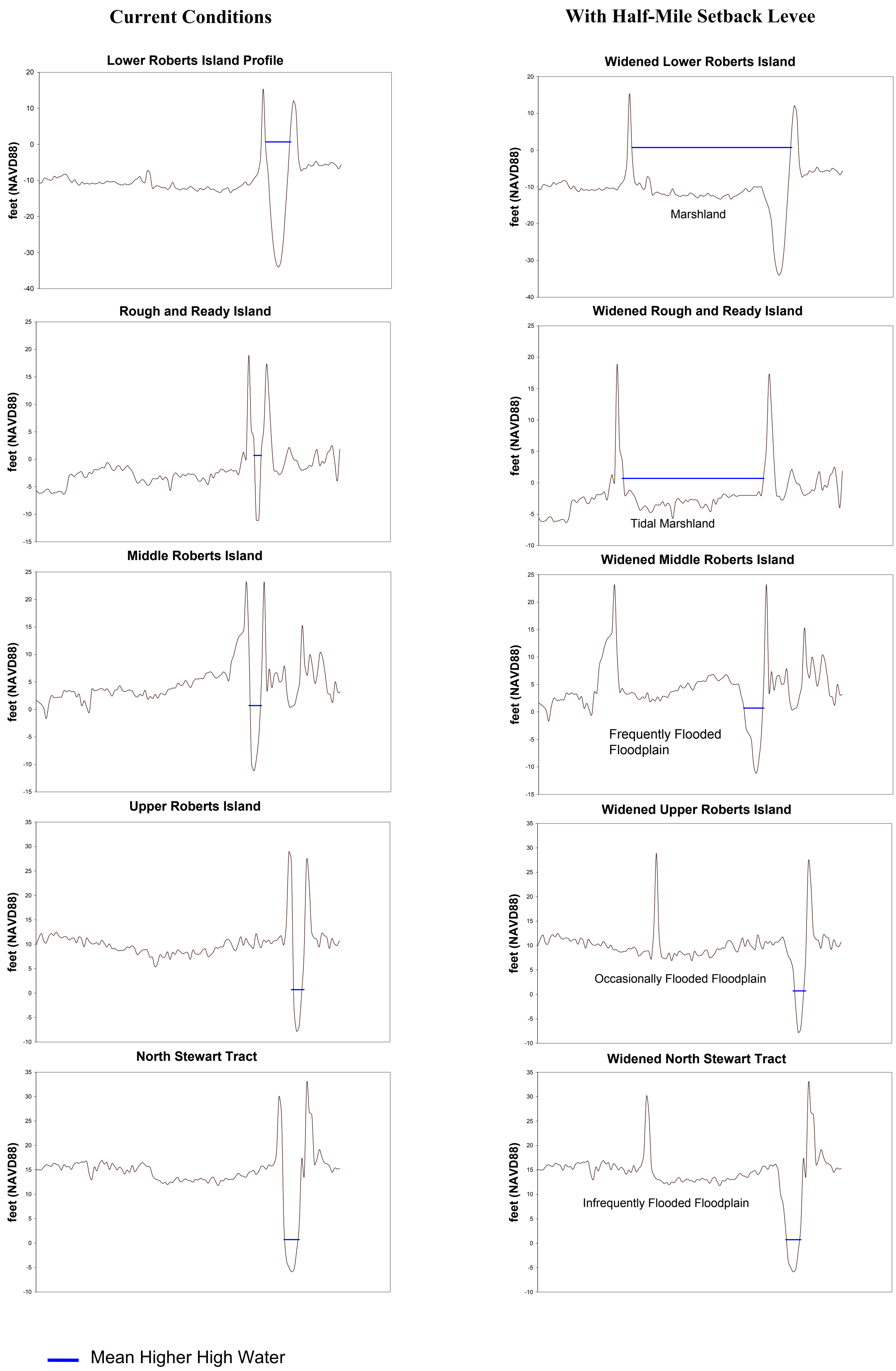


40 River mile marker

Cross section

Study area

URS	26815935 Delta Risk Management Strategy (DRMS) Phase 2	RIVER CROSS-SECTION LOCATIONS	Figure 10-5



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Delta Risk Management Strategy (DRMS)
Phase 2

COMPARISON OF CURRENT TO WIDENED CROSS SECTION
(MEAN HIGHER HIGH WATER INDICATIVE OF POTENTIAL FLOODPLAIN HABITAT TYPE)

Figure
10-6

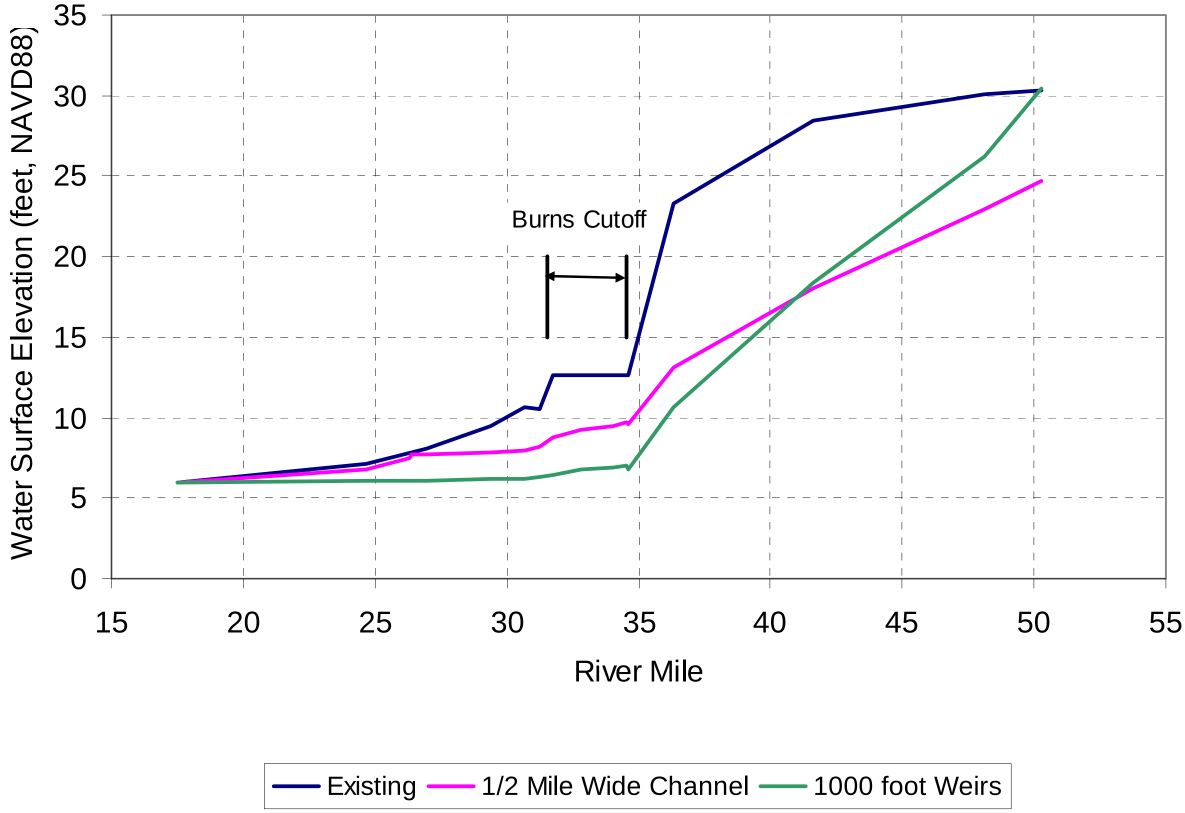

Figure 10-7 Water Surface Elevation in the San Joaquin River for San Joaquin Bypass Alternatives for January 1997 Storm Event

(Peak Flow at Vernalis = 75,600 cfs)

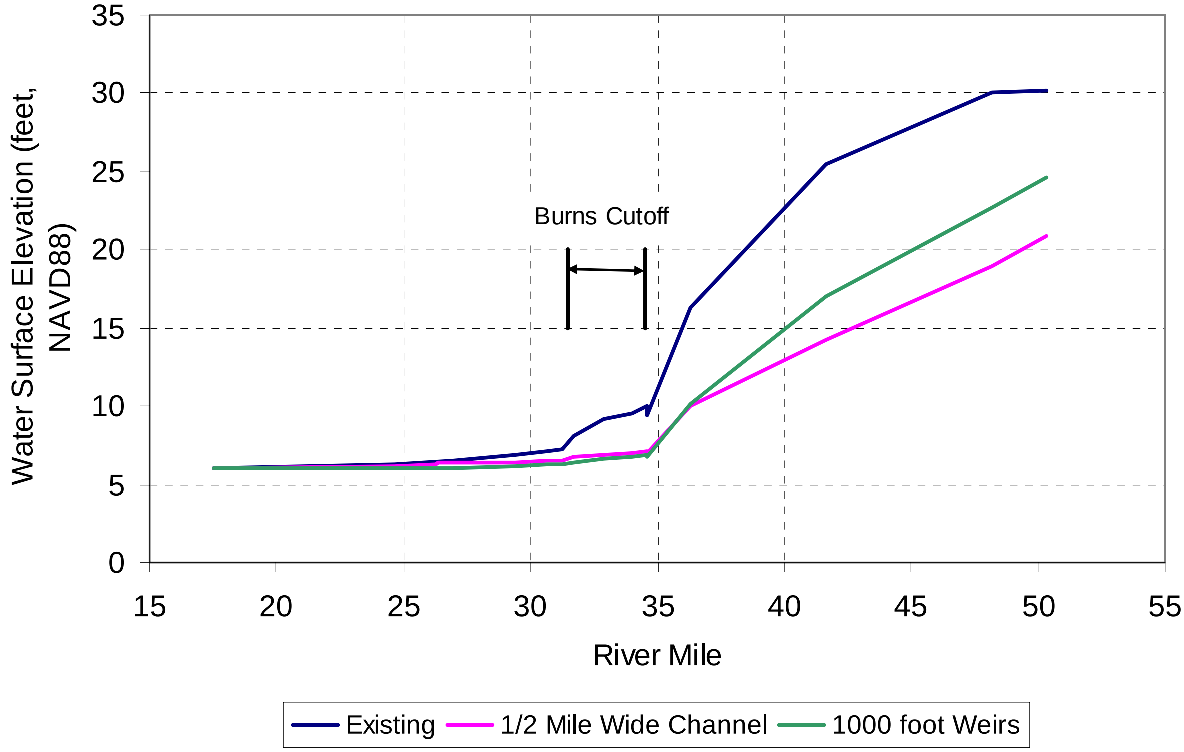

Figure 10-8 Water Surface Elevation in the San Joaquin River for San Joaquin Bypass Alternatives for April 2006 Storm Event

(Peak Flow at Vernalis = 34,800 cfs)

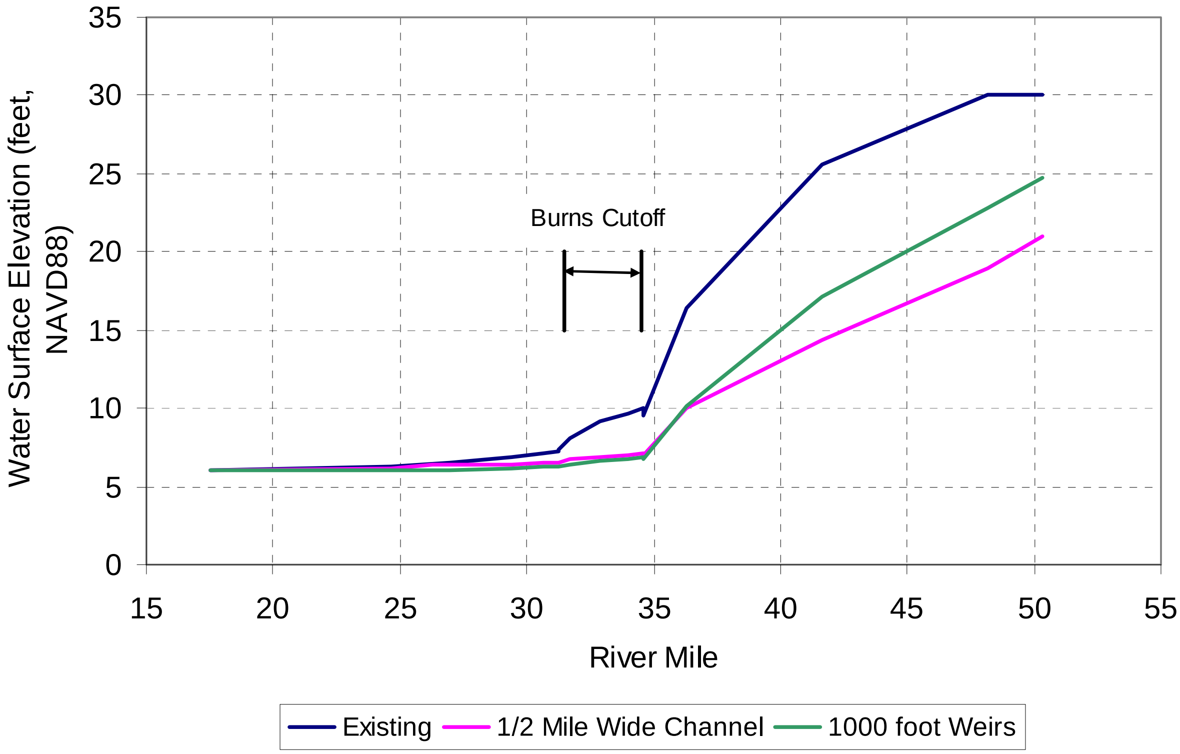

Figure 10-9 Water Surface Elevation in the San Joaquin River for San Joaquin Bypass Alternatives for February 1998 Storm Event

(Peak Flow at Vernalis = 35,200 cfs)

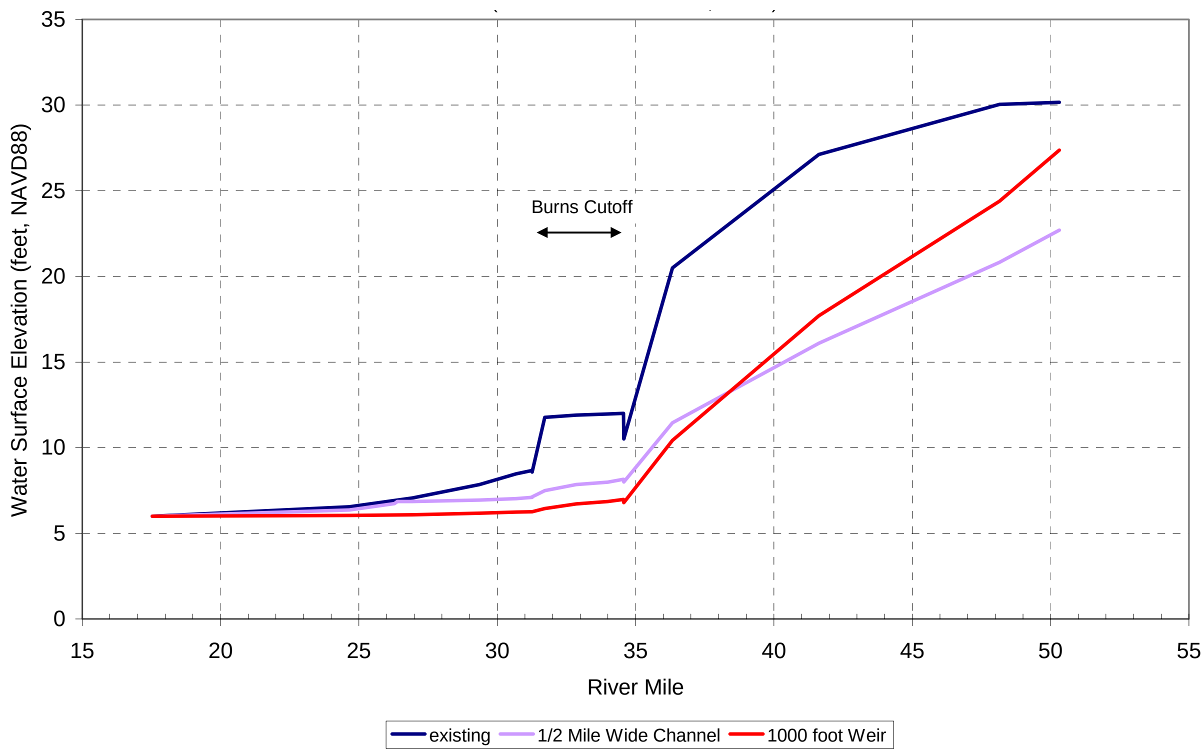

Figure 10-10 Water Surface Elevation in the San Joaquin River for San Joaquin Bypass Alternatives for January 1969 Storm Event

(Peak flow at Vernalis = 52,600 cfs)